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The Silicoflagellides in the Wakura Beds, Nanao City, Prefecture Ishikawa, Japan

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Introduction

This study on fossil flagellates is based on a diatomite, which was examined for fossil diatoms by W. Ichikawa in 1960 and was described as the type-material of the Wakura Beds. The samples were collected by W. Ichikawa himself in Nanao City, Pref. Ishikawa, Japan.

Geological data on the deposit were given in Ichikawa's publication "On the Fossil Diatoms of the Wakura Beds, Noto Peninsula, Japan". The strata were found to be of the miocene age.

Siliceous fossils constitute the greater part of the assemblage, calcareous microfossils are relatively rare. Triradiate forms of silicoflagellides, as they occur in high frequence in the early tertiary, are practically absent. Globular species of the genus *Cannopilus*, which in the evolution of the silicoflagellides rank among the best spezialized, are frequent. From this it can be concluded that the deposit of the Wakura Beds is of late tertiary age.

The silicoflagellides in the sample studied show a tendency to have long radiate horns, which prove that the living cells needed more help to keep floating than the short-horned forms of warm seas with high salinity. Considering the assemblage of

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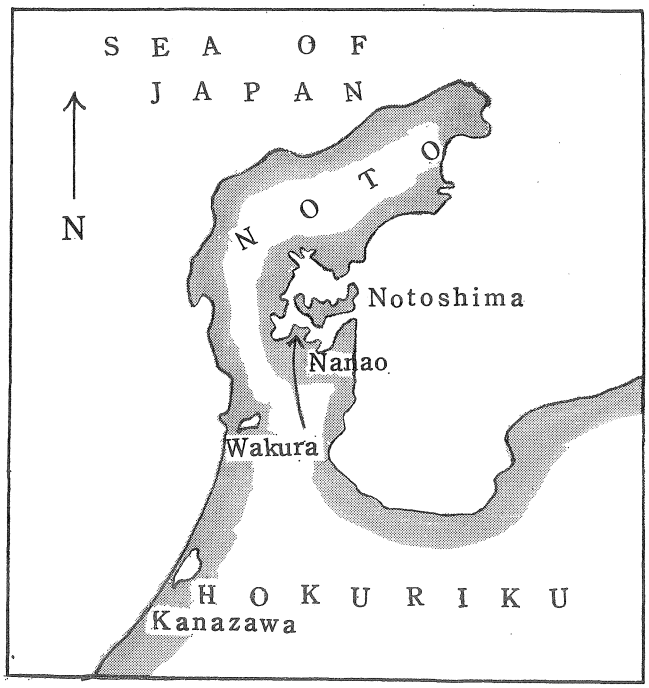

Figure 1. Index map showing the positions of Wakura and Noto-shima (Noto Island) in Nanao City.

diatoms described by ICHIKAWA the living condition of the silicoflagellides are thoght to have been those of a colder ocean with relatively moderate salt-contents.

The high percentage of pelagic diatoms and radiolaria gives hints to some of open sea condition. Also double-skeletons of silicoflagellides (*Dictyocha fibula*, *D. crux* and *D. speculum*) could be found.

Because of the wide variability of the silicoflagellides a detailed description of the different varieties and forms would have exceeded the available pages by far. Therefore varieties are mentioned under the headings of the species and no special descriptions of the sub-species are given except of *Corbisema triacantha* fa. *minor* and *Cannopilus schulzi* fa. *longispina*.

For help in compiling literature and for friendly advice the authors owe thanks to Prof. Dr. Georges DEFLANDRE, Paris, to Prof. Dr. Adolf PAPP, Vienna, Prof. Dr. Eugene J. TYNAN, Kingston, U. S. A. and Dr. Herbert STRADNER, Vienna.

General Geology

The Wakura Beds have ever been exploited as a sort of diatomite, and they are now widely used as a raw material of the fire-proof goods. The material studied here is produced from the outcrop of the quarry in the grounds of the Isolite Insulating Products Company which lie in the neighbourhood of Wakura Station, Noto Peninsula, Japan. The material is what people has called a diatomite. Yet thereby it is

not fit to remember at once a sort of whitish typical diatomite, rather it is a tuffaceous mudstone bearing diatoms and other microfossils.

The geology of Wakura-machi and its neighbourhood is easy to understand. The horizontal extent of the Wakura Beds lies nearly in a single circle whose diameter is about 2,000m, and its thickness amounts to 20-50m. The Beds are also widely connected with the diatomaceous deposits of Noto Island which is lying down in the center of Nanao Bay. Therefore, it is a legitimate conclusion that its distribution of the Wakura Beds attends to a fair area.

The rock is massive, its colour gray-light brown and its lamination scanty. The lower boundary of the Beds lies on the guloconite deposits whose thickness is about lm, and the upper part has been eroded and become a plane of erosion. But at the small parts of this area, the Wakura Beds are covered by the alternation of sand and gravel of the quarternary deposits which lie unconformably on the Beds. The diatomite can, therefore, easily be dug out in a way of openair mining.

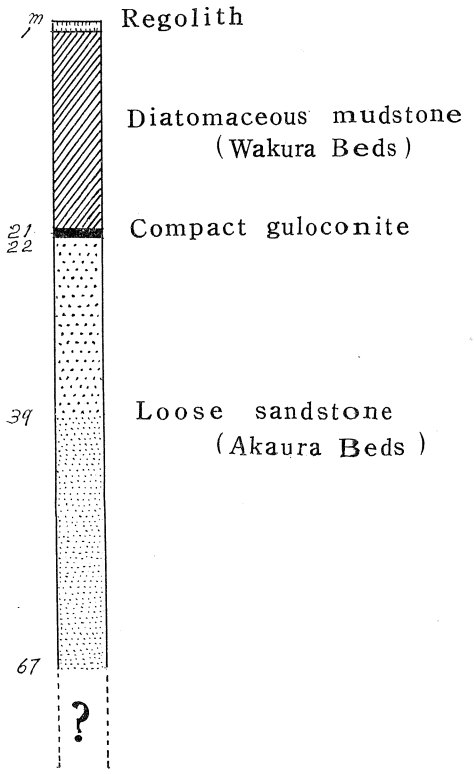

Figure 2. Composite columnar section at the Isolite Insulating Products Company near Wakura Station.

The strike of the Wakura Beds is NE-70° and its dip NW 6-10°. As a whole, the Beds are nearly horizontal or somewhat inclined towards the southern coast of Nanao Bay. According to some latest geological data, the Beds, belong to the miocene age of the Hokuriku District where such mudstones are found widely distributed.

The diatomite is being made use of in manufacturing most of fire-bricks or potable cooking furnances.

Methods of Preparation

The samples were cleaned from disturbing calcareous and organic particles by the following treatment :

1., Cracking of the rock by soaking with hydrogen-peroxide (+) (concentration 30%)

Footnote (+) : Protect your eyes while working with these chemicals by wearing goggles.

2., Decalcification by boiling in hydrochloric acid (30%) (+) for some minutes.
3., Rinsing of the sample by diluting with distilled water till neutral conditions are reached.
4., Boiling of the residue in concentrated sulphuric acid (+) for 30 minutes. After about 10 minutes of boiling a few crystals of salpeter (Potassium nitrate) are added, where=upon the black colour caused by carbon deriving from organic particles disappears (bleaching by means of nitrogen dioxide).
5., Careful addition of distilled water (drops only) till neutral conditions are established (test with litmus paper) (+)
6., Boiling in highly diluted caustic soda (sodium hydroxide, NaOH). Intermediate checking under the microscope is necessary. The dissolution of the menilite-concretion can be observed.

If the sample is cleaned sufficiently, some hydrochloric acid or some acetic acid is added to interrupt the solving process of the caustic soda and to prevent damage by corrosion of the tender siliceous forms.

The sedimentation of the diatoms and silicoflagellides after each rinsing-process takes about one hour after which time the clear water above the residue can be decanted. Separate fractions according to the size of the microfossils can be won by using metal-sieves with mashes from 0.03 - 0.06 mm. This method is very tedious work but it furnishes residues of optimal purity.

The cleaned type material was deposited by the authors in the Geological Institute of the Kanazawa University, Japan.

The preparation of the cleaned sample for microscopical purposes was done according to the conventional methods. A drop of the siliceous material was dried on the cover-glass, enclosed in "CÄDAX" (produced by the Bayer-Werke, Leverkusen in Germany) and covered by a microscopic slide (26 × 76 mm). If the microfossils are to be viewed from both sides, the cover-glass has to be covered by another cover-glass of the same thickness (0.1 mm). If carefully heated the enclosing medium CÄDAX hardens within a few minutes. Castor-oil may be used to show the minute lamina of the skeletons. As the castor-oil does not enter the interior of the skeletons as fast as CÄDAX does, it usually encloses some air bubbles within them, so that the size and the diameter of the hollow interior of the skeletons can be measured. The optical index of CÄDAX comes up to 1,55, that of castor-oil being much lower. For showing the surface ornamentation of the skeletons of the silicoflagellides a special enclosing medium with an optical index of 1,67 was used (compare Mikrokosmos, Jg. 1959, Nr. 12, Stuttgart, Germany)

A binocular microscope of the Reichert-Werke, Vienna, Austria, type BIOZET was used for most of the microscopic work. In some cases a phase-contrast equipment was of valuable help. A drawing-apparatus was employed for doing the ink drawings, for microphotography a PRACTIFLEX- camera was used. The author owes special thanks to Mr. Karl Adamek, Reichert-Werke, Vienna, for technical and

optical advices.

More than hundred microscopic slides in the authors collection of the Wakura Beds were examined for their contents of silicoflagellides mainly. Each specimen was registered, those specimens on which the drawing were based, were marked on the cover glass with a black ring of Indian ink. By this means they can be easily located for further examination at any given time. The percentages in the next diagram are based on a numerus of 1000.

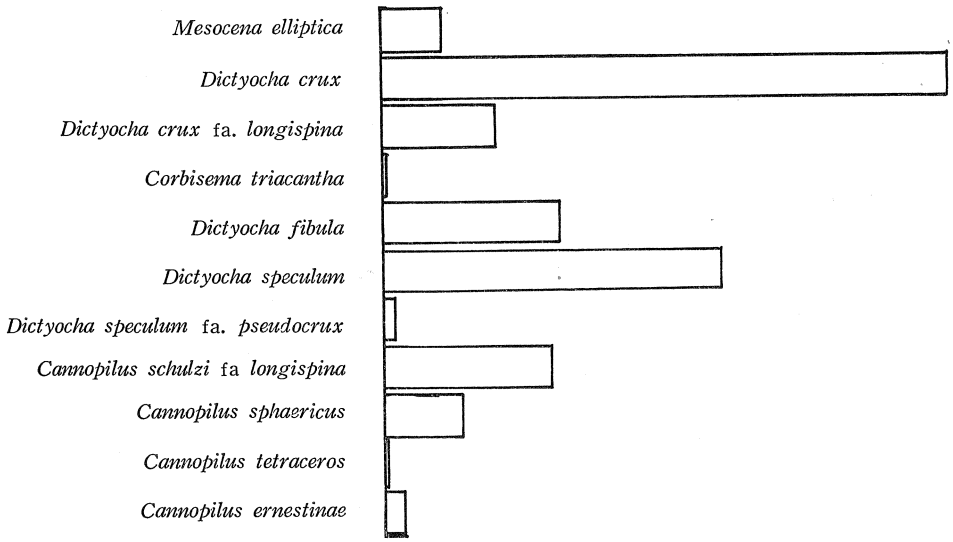

Figure 3. Distribution of the described species.

The size of the skeletons shown on the plates varies from 30μ to 120μ and can be determined with help of the measure line printed below each plate.

Surface Ornamentation and Double Skeletons

As first observed by DEFLANDRE in 1940 the skeletons of the silicoflagellides wear a surface pattern of minute dots connected by straight connection-lines. This ornamentation cannot be seen on all skeletons and it takes an extremely powerful optical equipment to make it visible. The optical index of the enclosing medium has to be high (more than 1,50). Tender skeletons usually do not show any ornamentation, not even in phase-contrast.

The ornamentation can be viewed best in those places of the skeletons where the surface is rather flat, that is at the junctions of the tubes. The apical parts of the skeletons have a more distinct ornamentation than the basal parts. Small skeletons generally have a finer and less visible ornamentation than big ones. Though the ornamentation cannot be considered of importance for the systematic of this group, a slight difference in the width of the mashes of the ornamentation seems

worth to be mentioned. The mashes of the ornamentation of the genus *Dictyocha* seem to more wide than those of the genus *Cannopilus*,

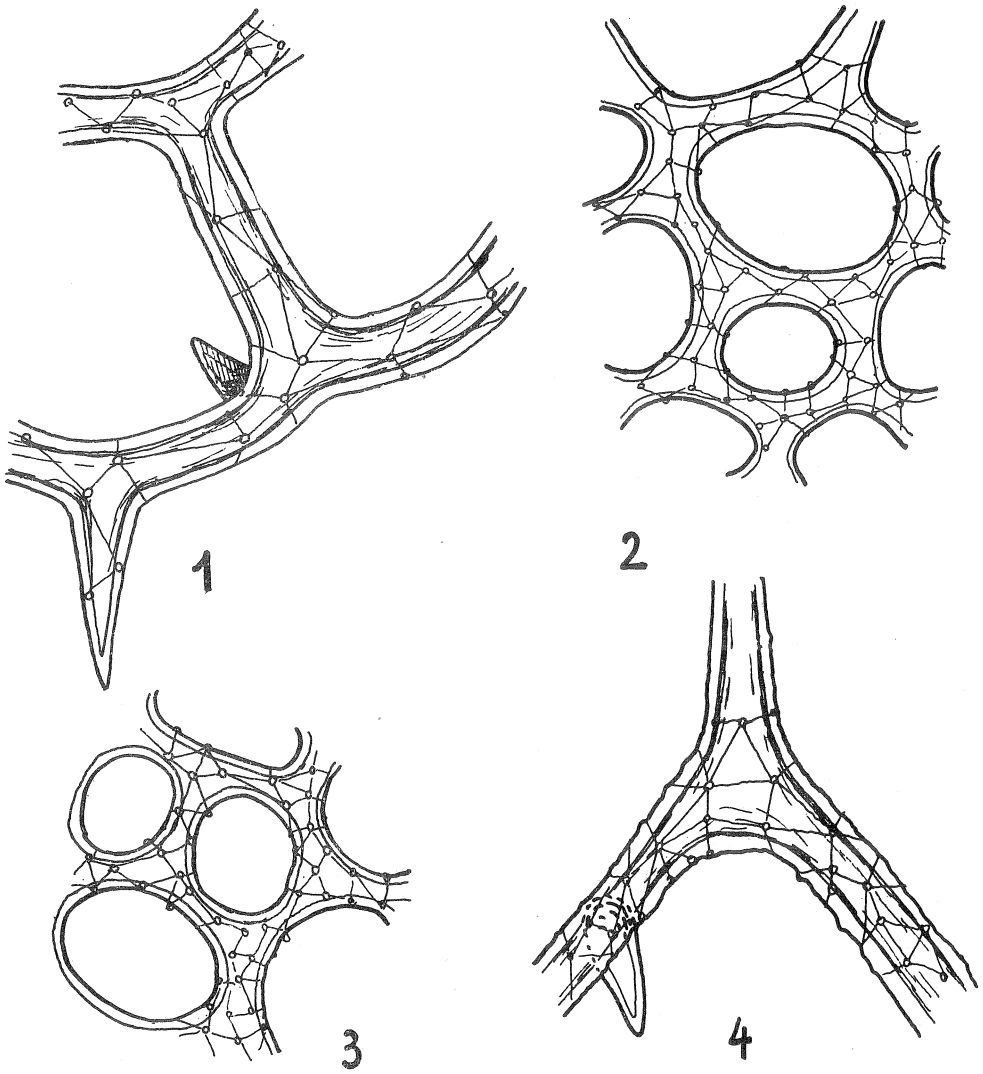

Figure 4. Surface ornamentations

1. *Dictyocha speculum* EHR.,
2. *Cannopilus schulzi* DEFL. fo. *longispina* n. fa.,
3. *Cannopilus sphaericus* GEM.,
4. *Dictyocha crux* EHR. (Orig. enlarg. 4000X)

Double skeletons are rather rare. They can be found occasionally in the species *Dictyocha fibula*, *D. crux* and *D. speculum* (see pl. 2, fig. 28 and pl. 7, fig. 13). The constituents of the double skeletons are two normal skeletons which are facing each other with their basal ring. It is a remarkable fact, that all those skeletons withstood the boiling in different acids without falling apart. From this it can be concluded that the living cells - while in the process of dividing-ceased living before completing cell-division.

Systematic Descriptions of the Species of Silicoflagellides encountered in the Diatomite of the Wakura Beds, Japan

Protista : Class : *Flagellata* COHN 1853
Order : *Silicoflagellatae* BORGERT 1891
Family : *Dictyochaceae* LEMMERMANN 1901
Genus : *Mesocena* EHRENBERG emend. DEFLANDRE

Mesocena elliptica EHR. emend. DEFLANDRE

1854 *Mesocena elliptica* EHR., Mikrogeologie, pl. XX, fig. 44
1854 *Mesocena Tripyla* EHR., Mikrogeologie, pl. XXI, fig. 41
1928 *Mesocena polymorpha* LEMM. var. *triangula* (EHR.) LEMM., SCHULZ, Beiträge···, p. 237, fig. 3 and var. *quadrangula* (EHR.) LEMM., p. 238, fig. 4
1930 *Mesocena crenulata* var. *elliptica* (EHR.) LEMM., GEMEINH., Silicoflagellatae, p. 27, fig. 11,
1930 *Mesocena polymorpha* var. *pentagona* LEMM., GEMEINH., Silicoflagellatae, p. 30, fig. 14 and var. *quadrangula* (EHR.) LEMM., p. 29, fig. 13
1932 *Mesocena polymorpha* LEMM. var. *quadrangula* (EHR.) LEMM., DEFLANDRE, Les Silicoflag., fig. 6
1940 *Mesocena elliptica* EHR., FRENGUELLI, Consideraciones···, fig. 9 b, d
1950 *Mesocena elliptica* EHR. emend. DEFLANDRE, Contribution···, figs. 78–80
1961 *Mesocena elliptica* EHR. emend. DEFL., STRADNER, Über foss. Silicofl···, p. 89, figs. 36–38 pl. 1, figs. 1–10 pl. 9, figs. 1–7

Siliceous skeletons consisting of a hollow ring, which is of elliptical or rhombical shape, with usually four, semetimes three or five short radial horns. The surface of the ring is covered with minute warts, which give the skeleton a rough appearence. In some skeletons the inner bore is very narrow, whereas with a smooth surface have a wider inner diameter. The former usually contain air, as the enclosing medium does not penetrate the thick siliceous wall so easily and therefore seem to be darker.

Occasionally there are remnants of a lateral arch to be found or even a complete lateral arch may be developed such as in pl. 1, figs. 7, 9, and 10. These additional tubes never are of regular distribution, but they prove that this species is related to the genus *Dictyocha*. Sometimes there are double or triple radial horns very near to each others (anomalies). The following variations could be disterned :

var. *triangula:* 3 radial horns; pl. 1, figs. 3 and 10
var. *quadrangula:* 4 radial horns; basal ring of quadrangular or rhombical outline; pl. 1, figs. 2, 6 and 8
var. *pentagona:* 5 radial horns; pl. 1, fig. 5

Hexagonal forms as described by ICHIKAWA (Preliminary Report··· 1956, see References) could not be found in this sample.

In this moderately frequent species the quadrangular forms are more abundant than the other forms.

Other occurences: Moron (Spain); Frättingsdorf (Lower Austria), Chico Martinez Creek (California, U. S. A.) and many other marine deposits

Genus: *Dictyocha* EHRENBERG 1839

Dictyocha crux EHRENBERG

1854 *Dictyocha crux* EHR., Mikrogeologie, Pl. XVIII, fig. 56
1928 *Distephanus crux* (EHR.) HAECKEL, SCHULZ, Beiträge···, p. 255, figs. 44, 45, and var. *Schauinslandii* p. 259, fig. 47 d
1928 *Distephanus regularis* LEMM., HANNA,. The Monterey Shale···, fig. 5
1930 *Distephanus crux* (EHR.) HAECKEL, GEMEINHARDT, Silicoflag···, p. 58, fig. 49 and var *mesophtalmus* (EHR.) LEMM., p. 58, fig. 50
1932 *Distephanus crux* (EHR.) HAECKEL, DEFLANDRE, Les Silicofl···, figs. 41–43
1950 *Dictyocha* cf. *D. crux* EHR., DEFLANDRE, Contribution···, fig. 89
1957 *Dictyocha crux* EHR., TYNAN, Silicofl. of the Calvert···, p. 131, pl. 1, figs. 3–8
1961 *Dictyocha crux* EHR., STRADNER, Über fossile Silicoflag···, p. 91, fig. 54 and fa. *longispina* SCHULZ, p. 92, fig. 56
pl. 1, figs. 11–15 pl. 2, figs. 20, 21, 34–36 pl. 3, figs. 37 and 38
pl. 7, figs. 1–8

Siliceous skeletons consisting of hollow tubes forming a basal ring with four horns and a smaller elevated apical ring. The basal ring is of rhombical outline, sometimes more oval than rhombical, and wears four radial horns in regular arrangement. Those two radial horns which lie in the main axis are usually built stronger and are longer than the ones in the direction of the shorter axis. Between the radial horns of the basal ring four lateral arches are inserted. These are supporting a small quadrangular apical ring, which is elevated over the centre of the skeleton. Viewed from the convexed side, the apical ring often shows a slight torsion to the left. Sustaining spines are protruding from the basal ring towards the centre of the concave face of the skeleton and are never situated exactly underneath the lateral arches as they are in the genus *Corbisema.*

Occasional abnormal forms with open basal rings or double horns or additional lateral arches can also be found.

var, *mesophtalmus:* round basal ring with four radial horns of equal lenghts and a large quadrangular apical ring; pl. 1, fig. 14

fa. *longispina:* Basal ring oval, apical ring twisted towards the left (counter clokwise) if viewed from the convexed side. The lateral radial horns are short stumps as compared to the very long ones in the direction of the main axis; pl. 2, figs. 16–19, pl. 7, fig. 9

On pl. 7, fig. 9 is shown a form, which is similar *Dictyocha schauinslandii* LEMMERMANN (*D. crux* EHR. fa. *Schauinslandii* LEMM.). Because of its smallness this form may belongs to *D. crux*.

Dictyocha crux is the most abundant species of the silicoflagellides in the sample of the Wakura Beds. Its variability and its difference in size are remarkable. Some forms have basal rings, which are slightly indented towards the centre of the skeleton (pl. 1, fig. 13, pl. 2, figs. 20, 35 and 36, pl. 3, figs. 37 and 38). The apical ring, which may be very small often wears supernumerary spines. Fig. 33 in plate 2 shows a form with an extremely small apical ring wearing a long supernumerary spine. This form is resembling *Dictyocha staurodon* EHRENBERG but it has been included in this species here as an anomaly only.

Other occurences: Redondo Beach (California, U. S. A.)=Malaga Cove, Frättingsdorf (Lower Austria), Marufa (Spain) and in many other tertiary diatomites of marine origin

Dictyocha fibula EHRENBERG

1854 *Dictyocha fibula* EHR., Mikrogeologie, pl. XIV, fig. 54 a, b, c
1928 *Dictyocha fibula* EHR. fa. *rhombica* SCHULZ, Beiträge···, p. 253, fig. 37 and fa. *constricta* SCHULZ, p. 253, fig. 37
1930 *Dictyocha fibula* EHR., fa. *rhombica* SCHULZ, GEMEINHARDT, Silicoflag···, p. 50, fig. 40
1930 *Dictyocha fibula* EHR., GEMEINHARDT, Silicoflag., p. 47, fig. 39 a, b
1932 *Dictyocha fibula* EHR. var. *aspera* LEMM., DEFLANDRE, Les Silicoflag···, fig. 33
1936 *Dictyocha fibula* EHR., DEFLANDRE, Les Flagellées···, fig. 52
1950 *Dictyocha fibula* EHR., DEFLANDRE, Contribution···, figs. 2–5
plate 2, figs. 24–33 plate 7, figs. 10–14

Siliceous tubular skeletons consisting of an either oval or rhombical basal ring with four radial horns and a simple apical apparatus without central window. The radial horns do not differ much in their lenghts. The places where the lateral arches are connected with the basal ring are slightly concave. The lateral arches unite to form an apical arch in the direction of the smaller diameter of the basal ring. The sustaining spines are sturdy and protruding towards the centre of the concave side of the skeleton. They are placed near the insertation of the lateral arches in the basal ring. The smaller forms of this species are outnumbering the bigger ones. Their surfaces are usually covered with little warts. Rare anomalies have open basal rings or double radial horns.

Typical forms: pl. 2, figs. 24, 26, 27; no typical forms: pl. 2, figs 25, 28–32
Other occurences: Maria Madre (Mexico), Hurcia (Spain) and in many other localities of tertiary age

Dictyocha speculum EHRENBERG

1854 *Dictyocha Speculum* EHR., Mikrogeologie, pl. XVIII, figs. 5–7
1854 *Dictyocha Ornamentum* EHR., Mikrogeologie, pl. XXI, fig. 48
1854 *Dictyocha Binoculus* EHR., Mikrogeologie, pl. XIX, fig. 42
1854 *Dictyocha diommata* EHR., Mikrogeologie, pl. XXXIII, fig. XVII 6
1854 *Dictyocha aculeata* EHR., Mikrogeologie, pl. XIX, fig. 40
1880 *Dictyocha aculeata* EHR., STÖHR, Die Radiolarien···, p. 120, pl. VII, fig. 7
1880 *Distephanus rotundus* STÖHR, EHR., STÖHR, Die Radiolarien···, p. 121, pl. VII, fig. 9
1901 *Distephanus speculum* EHR. (HCKL.) var. *pentagonus* LEMM., Silicoflag···, pl. XI, fig. 19
1901 *Cannopilus triommata* (EHR.) LEMM., Silicoflag., pl. XI, fig. 25
1928 *Distephanus ornamentus* (EHR.) HANNA, The Monterey Shale···, pl. 9, fig. 9
1928 *Distephanus speculum* EHR. fa. *coronata* SCHULZ, Beiträge···, p. 262, fig. 50
1928 *Distephanus speculum* EHR. var. *regularis*, fa. *coronata* SCHULZ, Beiträge···, p. 262, fig. 54
1928 *Distephanus speculum* (EHR.) HCKL., fa. *pseudocrux* SCHULZ, Beiträge···, p. 263, fig, 52
1930 *Distephanus speculum* (EHR.) HCKL., GEMEINHARDT, Silicoflag···, p. 61, fig 53
1931 *Distephanus variabilis* HANNA, Diatoms and Silicoflag···, pl. D, fig. 8; pl. E, figs. 5, 6
1931 *Distephanus irregularis* HANNA, Diatoms and Silicoflag···, pl E, figs. 8, 9 at *Corbis. triac.*
1931 *Corbisema triacantha* (EHRENBERG) HANNA, Diatoms and Silicoflag···, pl. D, fig. 1
1932 *Distephanus speculum* (EHR.) HCKL., DEFLANDRE, Les Silicofl···, fig. 45
1940 *Dictyocha speculum* EHR., FRENGUELLI, Consideraciones···, fig. 1 a–e
1950 *Dictyocha speculum* EHR., DEFLANDRE, Contribution···, figs. 1, 6, 7, 90, 121
1957 *Dictyocha speculum* EHR., TYNAN, Silicoflag. of the Calvert···, p. 132, pl. 1, figs. 11–19
1961 *Dictyocha speculum* EHR., STRADNER, Über fossile Silicofl···, p. 92, figs. 70–81
plate 3, figs. 39–56 plate 8, figs. 7–12

The skeletons of this species consist of siliceous tubular basal and apical rings of hexagonal symmetry. The outline of the basal ring is usually circular, only few skeletons show a tendency to extension in one direction thus forming an oval basal ring. Between the equally long radial horns, which extend in distal direction from the basal ring, there are lateral arches. These are slightly curved and hold up an apical ring of smaller diameter than the basal ring. The apical ring usually has the same number of angles as the basal ring. Sustaining spines are also inserted between the radial horns. They are short and sturdy and are pointing towards the centre of the skeletons. The apical ring often wears additional spines.

Distephanus rotundus as described by STÖHR in 1880 may be taken for a double skeleton. *Dictyocha aculeata* by the same author seems to be a form with extraordinarily regular distribution of the additional spines.

Some rare skeletons with three or four apical windows can be regarded as transitional forms to the genus *Cannopilus*. It is the writer's opinions that such forms are to be included in the species *Dictyocha speculum* because of their similar of the basal ring.

This species is very frequent and shows much variations in size.

fa. *pseudocrux*: six-rayed basal ring without sustaining spines, having one, two or three apical windows in the centre of the apical apparatus. pl. 3, figs. 39–44

var. *pentagonus*: five-rayed basal ring; pl. 3, figs. 46, 47, 55

var. *septenarius*: seven-rayed basal ring; pl. 3, fig. 49

Cannopilus triommata: three apical windows; pl. 3, fig. 51

Other occurences: Lompoc (California, U. S. A.), Marufa (Spain) and Maria Madre (Mexico)

Genus: *Corbisema* HANNA 1927

Corbisema triacantha (EHR.) fa. ***minor*** SCHULZ

1844 *Dictyocha triacantha* EHR., Monatsberichte (ex GEMEINH. 1930)

1854 *Dictyocha triommata* EHR., Mikrogeologie, pl. XXXIII, fig. XV/11

1928 *Dictyocha triacantha* EHR, fa. *minor* SCHULZ, Beiträge···, p. 247, fig. 25 a, b

1930 *Dictyocha triacantha* EHR., DEFLANDRE, Les Silicoflagell···, fig. 27

1940 *Corbisema triacantha* (EHR.) sens. lat., DEFLANDRE, Sur une structure···, p. 446, fig. 3

1950 *Corbisema triacantha* (EHR.) DEFLANDRE, Contribution···, p. 54

1961 *Corbisema triacantha* (EHR.) STRADNER, Über fossile Silic···, p. 89, fig. 3

plate 2, figs. 22 and 23 plate 8, figs 1 nnd 2

Siliceous skeletons consisting of hollow tubes forming a basal ring shaped like an equilateral triangle the corners of which are extended into long radial horns. Three lateral arches are inserted into this basal ring between the radial horns and unite in the centre of the skeleton without forming a lamina or an apical window. Those places where the lateral arches are connected with the basal ring are slightly concave. The skeletons usually have very narrow inner bores. Their surfaces are smooth and they show only little variation in size and shape.

STRADNER in 1961 described a new variety of this species from an oligocene diatomaceous marl of Upper Austria as *var. flexuosa*, which shows much similarity to the forms of the Wakura Beds except being smaller and having a twisted basal ring.

Other occurences: Frättingsdorf and Ameis (Lower Austria)

Genus: *Cannopilus* HAECKEL 1889

Cannopilus schulzi DEFLANDRE fa. ***longispina*** n. fa.

1949 *Cannopilus schulzi* DEFLANDRE (=*Cannopilus cyrtoides* SCHULZ non HAECKEL) DEFLANDRE, in prep.

Derivation of name: longispina = with long thorns

Holotype: Prep. WAK 1, No. 6

Type locality: Nanao City, Pref. Ishikawa, Japan

Type strata: Upper miocene- pliocene

plate 4, figs. 57–70 plate 8, figs. 3–6

Siliceous skeletons consisting of an octagonal basal ring with eight radial horns and a complicated apical apparatus. Those two radial horns, which lie in the main axis are much longer than all the other six horns. In some skeletons the pair of lateral horns in the direction of the shorter diameter may be substituted by curved

arches of the basal ring without any distal extensions (compare pl 4, figs. 59, 60, 63, 64). Also such skeletons have eight short sturdy sustaining spines protruding towards the centre of the skeleton. The lateral arches are inserted in the basal ring between the radial horns and wear the apical apparatus which is shaped like a basket. The apical arches frame several, seldom only one, large apical windows of different size. The newly described form is distinctly extended in the direction of the main axis the radial horns in that direction always being very longer, thus differing from DEFLANDRE's species *Cannopilus schulzi*. Additional spines are seldom missing.

Skeletons with open basal rings, double radial horns or partially reduced radial horns are considered as anomalies.

HAECKEL in 1887 described an octagonal form as *Dictyocha cyrtoides*, which has 16 sustaining spines however. SCHULZ in 1928 described an octagonal form with eight radial horns and sustaining spines as *Cannopilus cyrtoides* HAECKEL (SCHULZ Beiträge ·····, figs. 65 and 66, HAECKEL, Report ·····, p. 1569, pl. 114, figs. 11 and 12) DEFLANDRE recently has come to the conclusion that the species described by SCHULZ is not identical with that described by HAECKEL and therefore proposes the new name *Cannopilus schulzi*, with this new species not being published yet the author participating in DEFLANDRE, opnion acknowledges DEFLANDRE's species though it has no been appeared in press yet.

Other occurences: Breitenaich (Upper Austria, Oligocene)

Cannopilus tetraceros DEFLANDRE

1949 *Cannopilus tetraceros* DEFLANDRE (in prep.)

Derivation of name: tetraceos = with four horns

Type locality: Prep. BE 2. 27/33 (Deflandre's collection), Moron (Spain)
plate 5, figs. 73–75 plate 9, figs. 8 and 11

Siliceous skeletons consisting of a quadrangular tubular basal ring and a complicated globular apical apparatus with approximately 40 apical windows. The radial horns are extending in lateral direction. The lateral arches enclose windows which are not any larger than the apical windows. The apical apparatus is domed to form a globular construction of a greater diameter than the basal ring has. No sustaining spines. One skeleton with only two radial horns and two additional horns inserted at the top of the apical apparatus was also included here.

This species, which according to a letter from DEFLANDRE (30. 11. 1961) has been discovered by him but not been published yet, is acknowledged here for reasons of fairness.

Cannopilus sphaericus GEMEINHARDT

1931 *Cannopilus sphaericus* GEMEINHARDT, Organismenformen···, p. 104, pl. X, figs. 3 and 4

1940 *Cannopilus sphaericus* GEM., FRENGUELLI, Consideraciones···, fig. 6 e
1950 *Cannopilus sphaericus* GEM., DEFLANDRE, Contribution···, figs. 95–97
1961 *Cannopilus sphaericus* GEM., STRADNER, Über fossile···, p. 92, figs. 99 and 100
plate 5. figs. 71, 72, 76–82 plate 9, figs. 9 and 10
plate 10, figs. 1–3

Skeletons consisting of siliceous tubes forming a six-nine-rayed basal ring with a complicated globular apparatus. The basal ring is of circular or regularly polygonal outline. Its radial horns are long and straight. They stick out in lateral direction. Sustaining spines are generally absent and only in seldom cases such as shown in present. The lateral arches are inserted in the basal ring between the radial horns and wear a globular apical apparatus the trellis if which encloses 30 -40 more or less circular apical windows. Those windows framed by the lateral arches are bigger than the apical windows. Additional spines belong to the regular equipment of this species. On some skeleton there is only a single additional spine of the size of a radial horn protruding from the top of the apical apparatus.

From the stratigraphical viewpoint *Cannopilus sphaericus* is considered to be a species high up in the progressive frequence within this genus. The higher developed the species are the more apical windows they construct. *Cannopilus picassoi* STRADNER with five dozens of apical windows is at the present time the highest developed species known. (see STRADNER, Über fossile Silicoflagelliden p. 92, figs. 101-104)

Other occurences : Szurdokpüspöki, and Karand (Hungary), Malaga Cove (California, U. S. A.), San Diego (Calif. U. S. A.) and Frättingsdorf (Lower Austria)

In the Austrian deposits the skeletons of this species wear sustaining spines.

Cannopilus ernestinae BACHMANN

1962 *Cannopilus ernestinae* BACHMANN, Eine neu entdeckte Silicof···, p. 255
Derivation of name : Dedicated to the memory of Ernestine Jurkovic, died in 1961
Holotype : Prep. WAK 1, no. 8 (pl. 6. fig. 89)
Type locality : Nanao City, Pref. Ishikawa, Japan,
Type strata : Upper miocene – pliocene
plate 6, figs. 83–92 plate 10, figs. 4–7

Siliceous skeletons of the "*Cannopilus sphaericus*" -type from which they differ by having a small number of large-sized lateral windows and a regularly pentagonal basal ring. The outline of the basal ring is pentagonal, seldom hexagonal. The radial horns are long and straight. The lateral arches enclose lateral windows, which are about four times as large as the apical windows. The apical windows (no more than seven) are very small compared to the lateral windows. Viewed from the top the skeletons show some resemblance to *Cannopilus hemisphaericus*, from which they can be easily discerned by their extreme doming of the apical apparatus. On top of the apical apparatus there is a long additional spine, which

can be surrounded by some smaller ones. No sustaining spines. This species is moderately frequent.

Other occurences : Szurdokpüspöky (Hungary)

Summary

The Wakura Beds which the sample is collected belong to the miocene age. The same beds are commonly found in the tertiary formations composing the oil fields along the coast of Japan Sea. These beds including the Wakura Beds are of great use in geological research as key beds, if the assemblages of fossil microorganisms such as silicoflagellides, diatoms, etc. are closely inspected.

A sample of diatomaceous earth from the Wakura Beds, Nanao City, Pref. Ishikawa, Japan, has been studied for its contents of sillicoflagellides, which are described and documented with drawings and microphotographs.

Nine species belonging to four genera could be encountered, three of which have not been described before.

Also the minute superficial ornamentations of the skeletons are mentioned in Figure 4 and shown on pages 165-167. The distribution of the species is given in a diagram on page 165. The cleaning-methods applied for gaining clean samples are discussed in a separate chapter and views on the possible environment of the silicoflagellides found in fossil state are expressed.

Eine Probe des Diatomites aus den Wakura Beds, Nanao City, Pref. Ishikawa in Japan wurde auf seinen Inhalt an Silicoflagelliden geprüft und die gewonnenen Erkenntnisse in Form einer Beschreibung, durch Zeichnungen und Mikrofotos festgehalten.

Es werden neun Arten beschrieben, die zu vier Genera gehören. Drei Arten sind hier erstmalig beschrieben.

Die Oberflächenstruktur der Silicoflagelliden wird erwähnt und abgebildet (Seite…165-167)

Die zahlenmäßige Verteilung der einzelnen Arten ist in einem Diagramm festgehalten. Es werden auch die Methoden zur Reinigung und Präparation in einem separaten Kapitel geschildert. Über die geologischen Gegebenheiten dieses Fundpunktes wird berichtet.

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1963 BACHMANN, A. "Silicoflagelliden" Mikrokosmos, Stuttgart (in print)

PLATE 1

Explanation of Plate 1

fig. 1-10	*Mesocena elliptica* Ehr.
fig. 11-13, 15	*Dictyocha crux* Ehr.
fig. 14	*Dictyocha crux* Ehr. var *mesophtalmus*

The Silicoflagellides in the Wakura Beds, Nanao City, Pref. Ishikawa, Japan

Plate 1

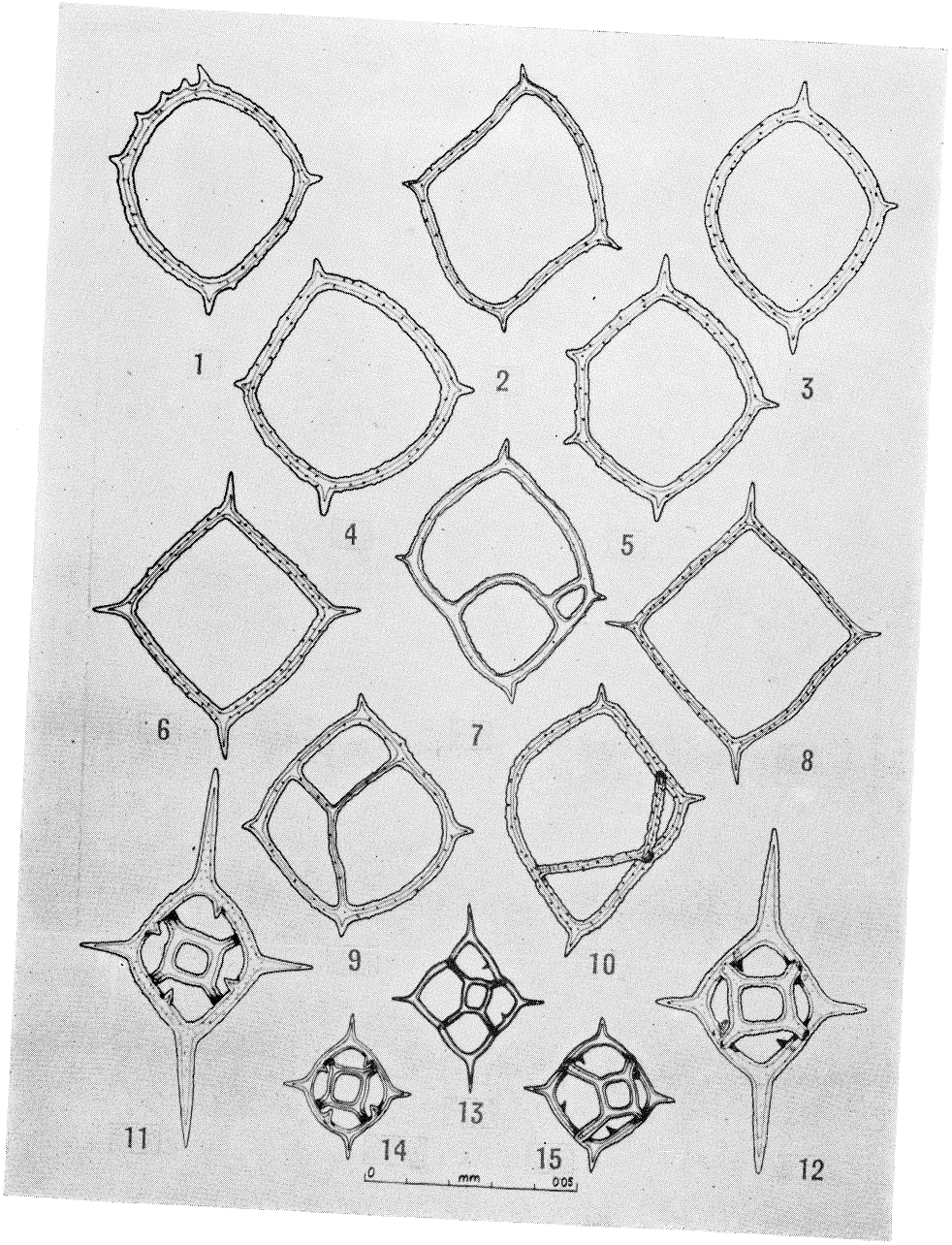

PLATE 2

Explanation of Plate 2

fig. 20, 21, 34-36	*Dictyocha crux* Ehr.
fig. 16-19	*Dictyocha crux* Ehr. fa. *longispina* Schulz
fig. 22, 23	*Corbisema triacantha* (Ehr.) fa. *minor* Schulz
fig. 24-33	*Dictyocha fibula* Ehr.

The Silicoflagellides in the Wakura Beds, Nanao City, Pref. Ishikawa, Japan

Plate 2

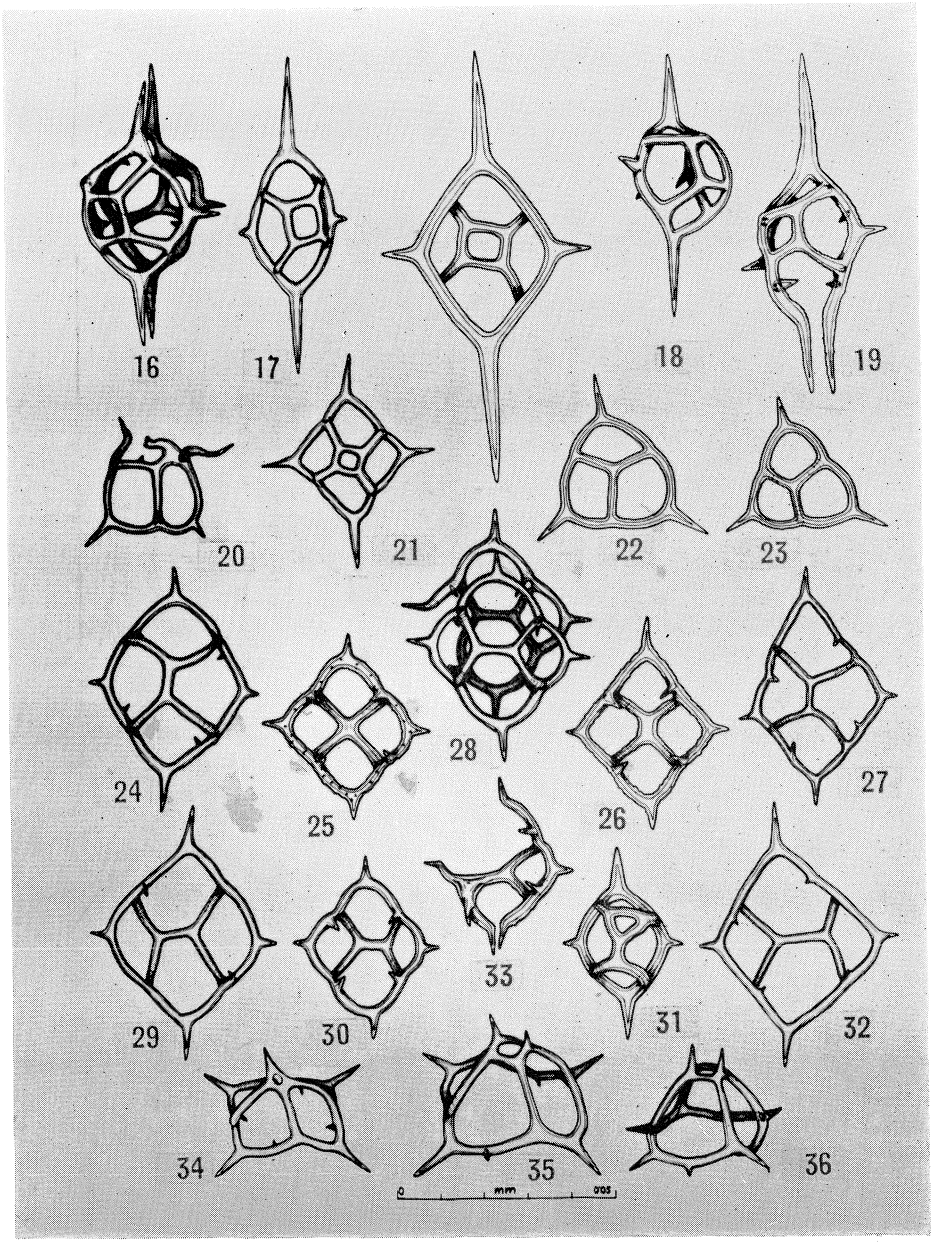

PLATE 3

Explanation of Plate 3

fig. 39-56	*Dictyocha speculum* Ehr. diff. form
fig. 37, 38	*Dictyocha crux* Ehr.

The Silicoflagellides in the Wakura Beds, Nanao City, Pref. Ishikawa, Japan

Plate 3

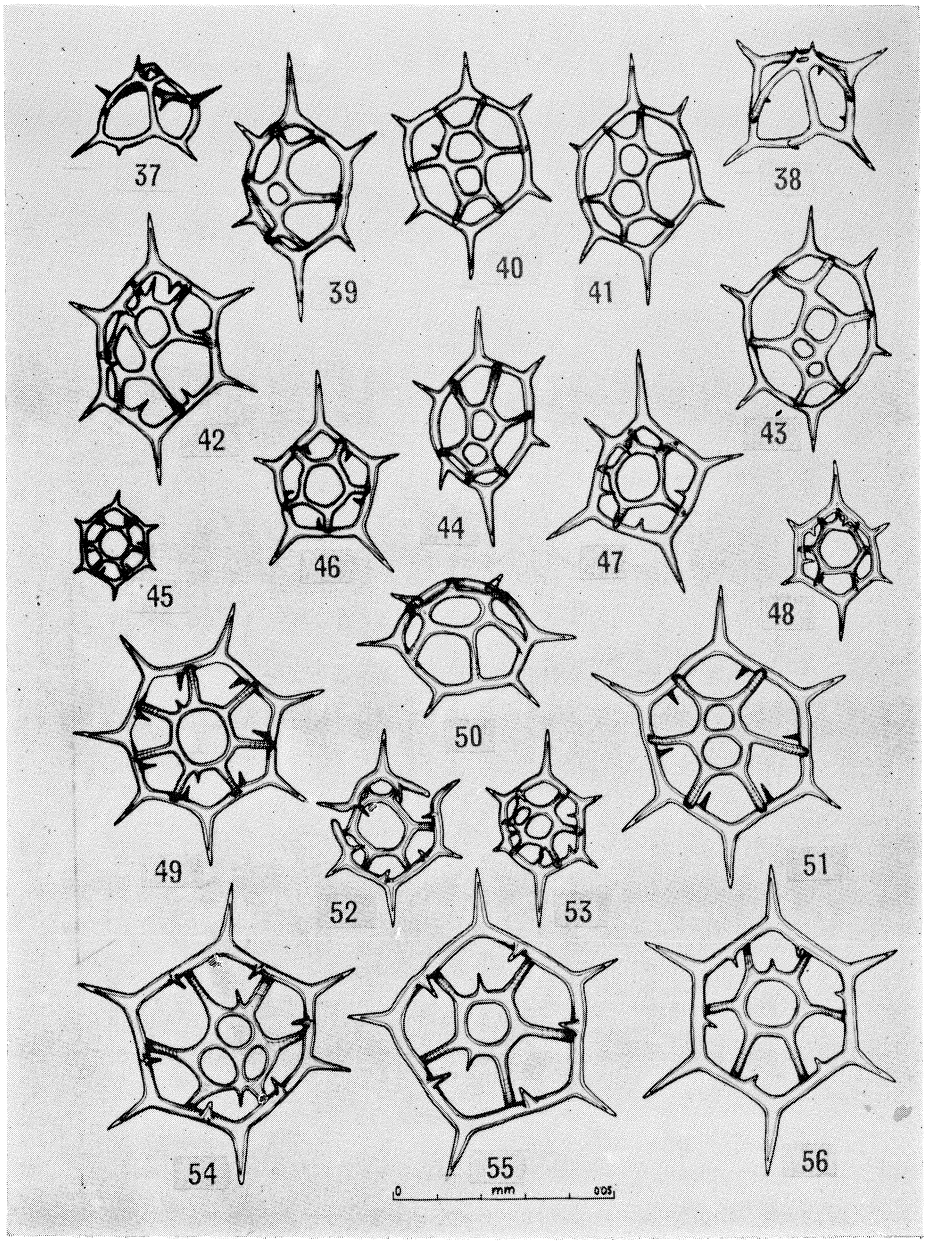

PLATE 4

Explanation of Plate 4

fig. 57-70 *Cannopilus schulzi* Deflandre fa. *longispina* n. fa.

Plate 4

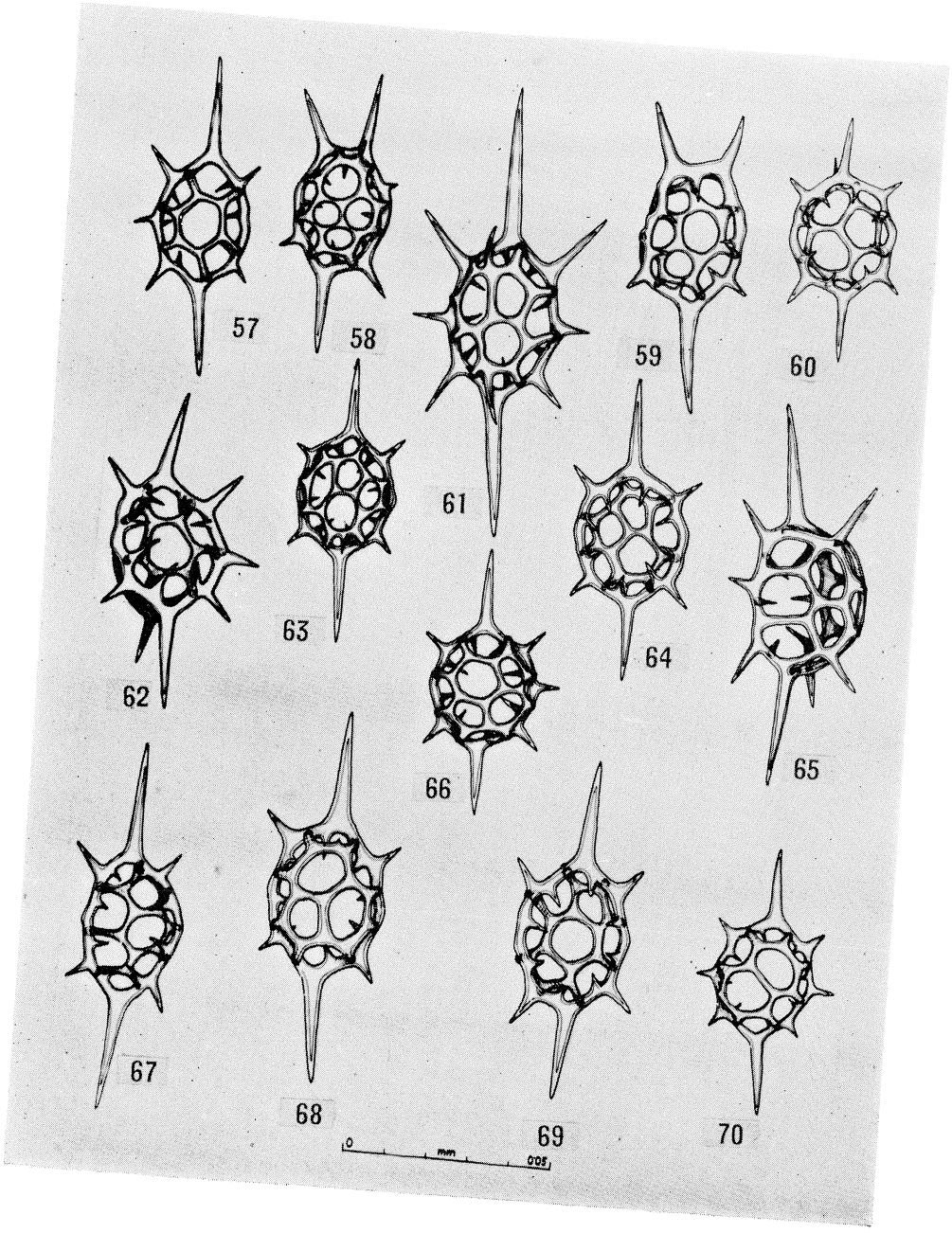

PLATE 5

Explanation of Plate 5

fig. 71, 72, 76-82 *Cannopilus sphaericus* Gem.

fig. 73-75 *Cannopilus tetraceros* Deflandre

Plate 5

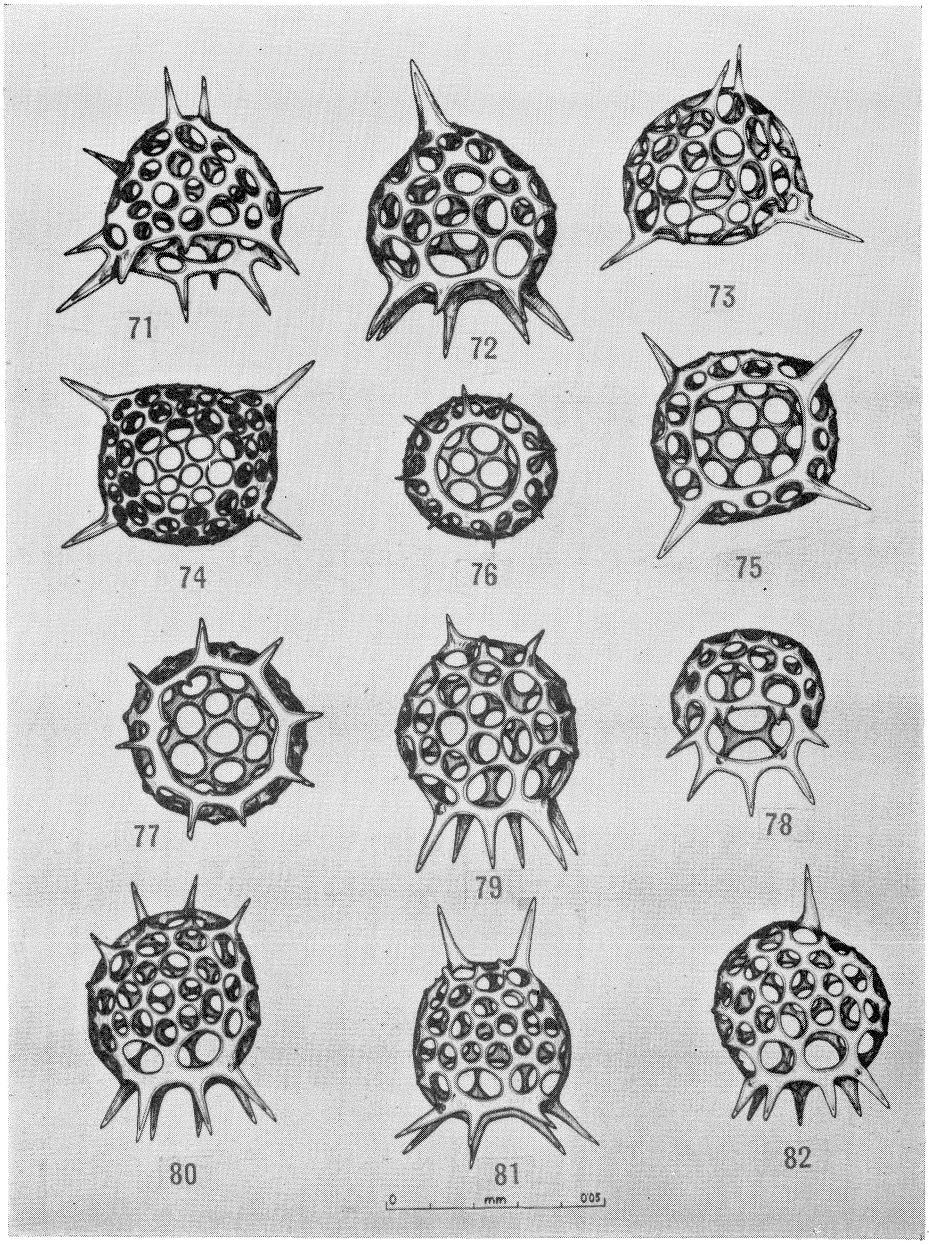

PLATE 6

Explanation of Plate 6

fig. 83-92	*Cannopilus ernestinae* Bachmann
fig. 93	not identified anomalous skeleton
fig. 94	anomalous skeleton of *Dictyocha speculum* Ehr.

Plate 6

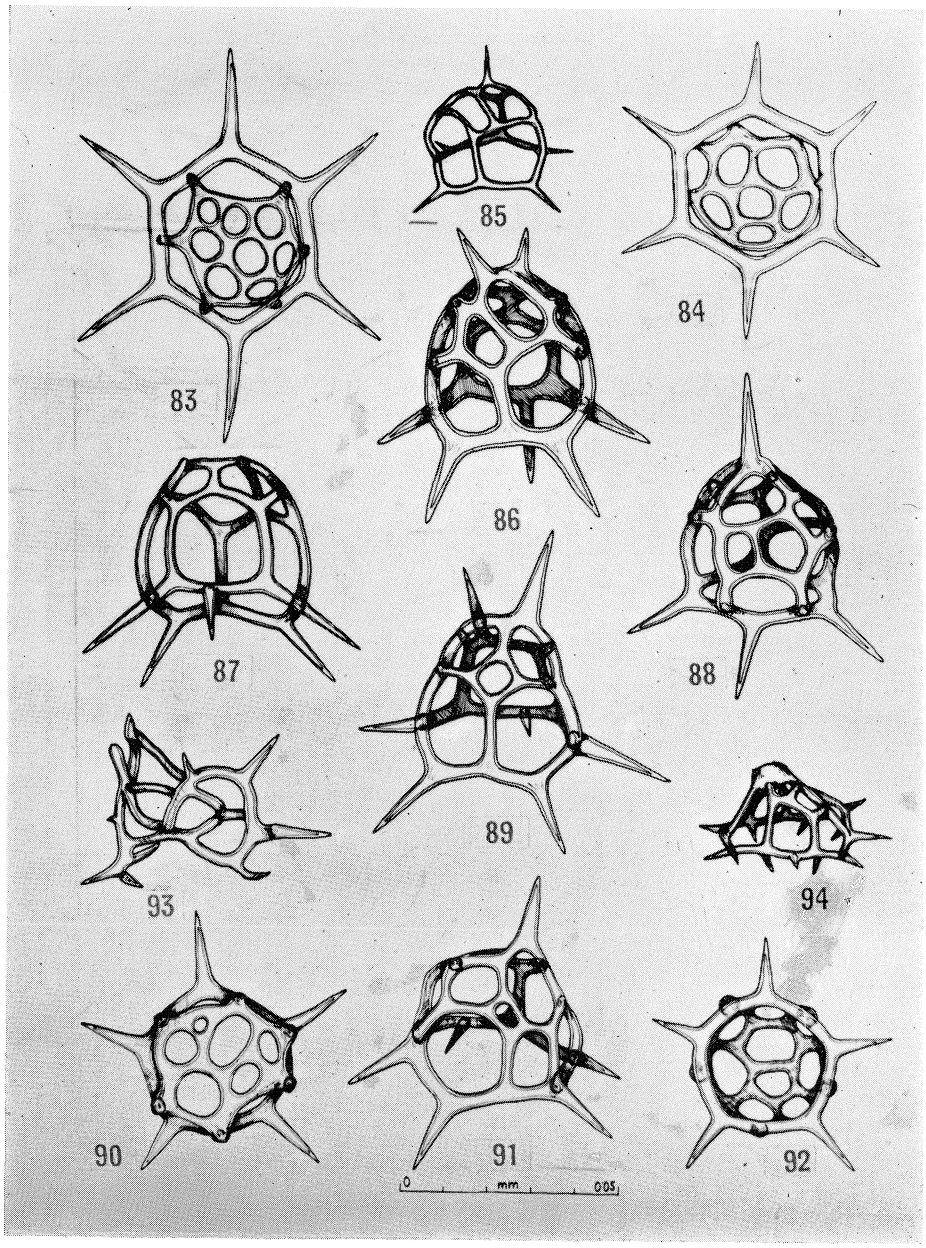

PLATE 7

Explanation of Plate 7

fig. 1-8	*Dictyocha crux* Ehr.
fig. 9	*Dictyocha crux* Ehr. fa. *longispina* Schulz
fig. 10-14	*Dictyocha fibula* Ehr.

Plate 7

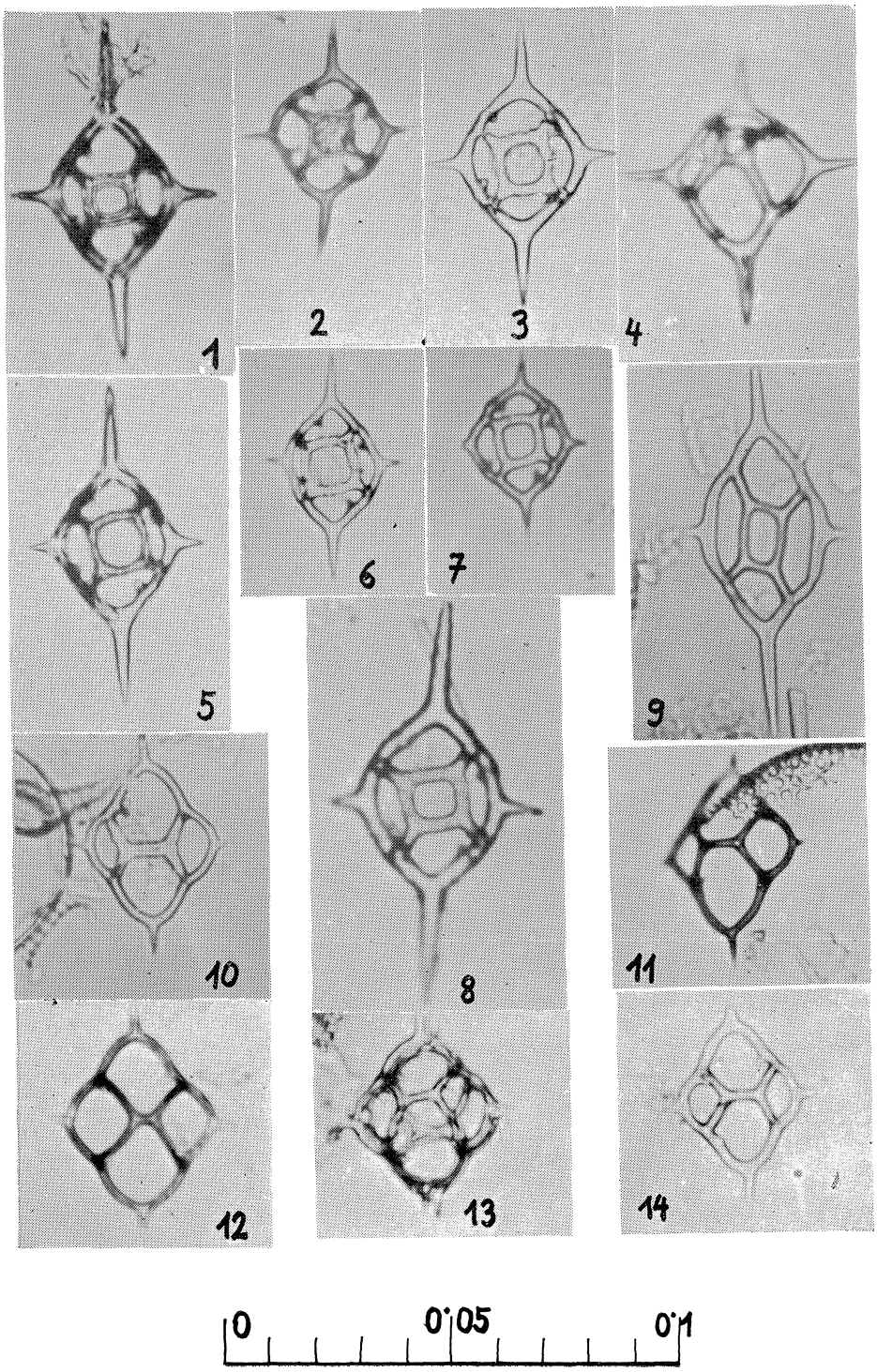

PLATE 8

Explanation of Plate 8

fig. 1 and 2	*Corbisema triacantha* (Ehr.) fa. *minor* Schulz
fig. 3-6	*Cannopilus schulzi* Deflandre fa. *longispina* n. fa.
fig. 7-12	*Dictyocha speculum* Ehr.

Plate 8

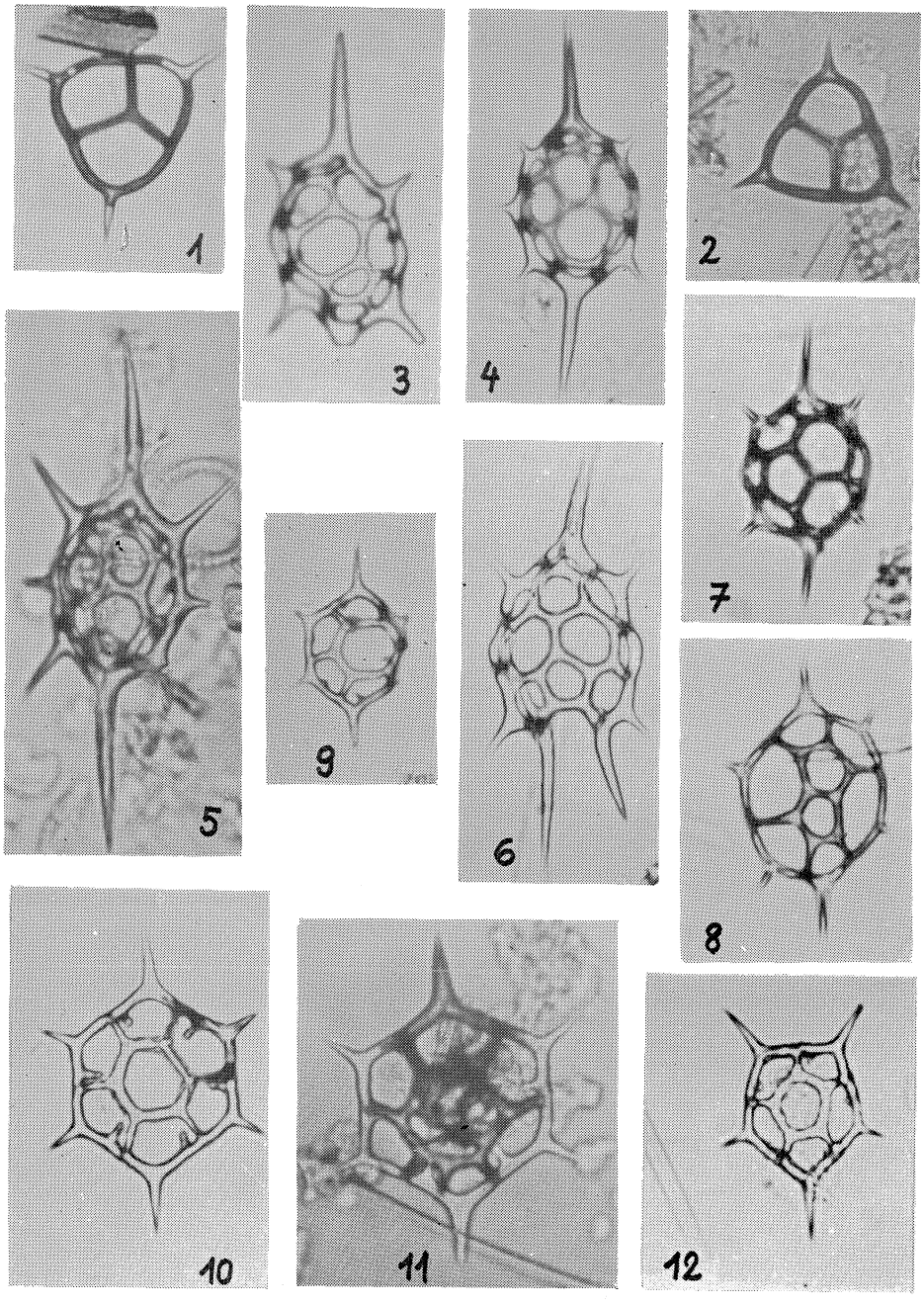

PLATE 9

Explanation of Plate 9

fig. 1-7	*Mesocena elliptica* Ehr.
fig. 8 and 11	*Cannopilus tetraceros* Deflandre
fig. 9 and 10	*Cannopilus sphaericus* Gemeinh.

Plate 9

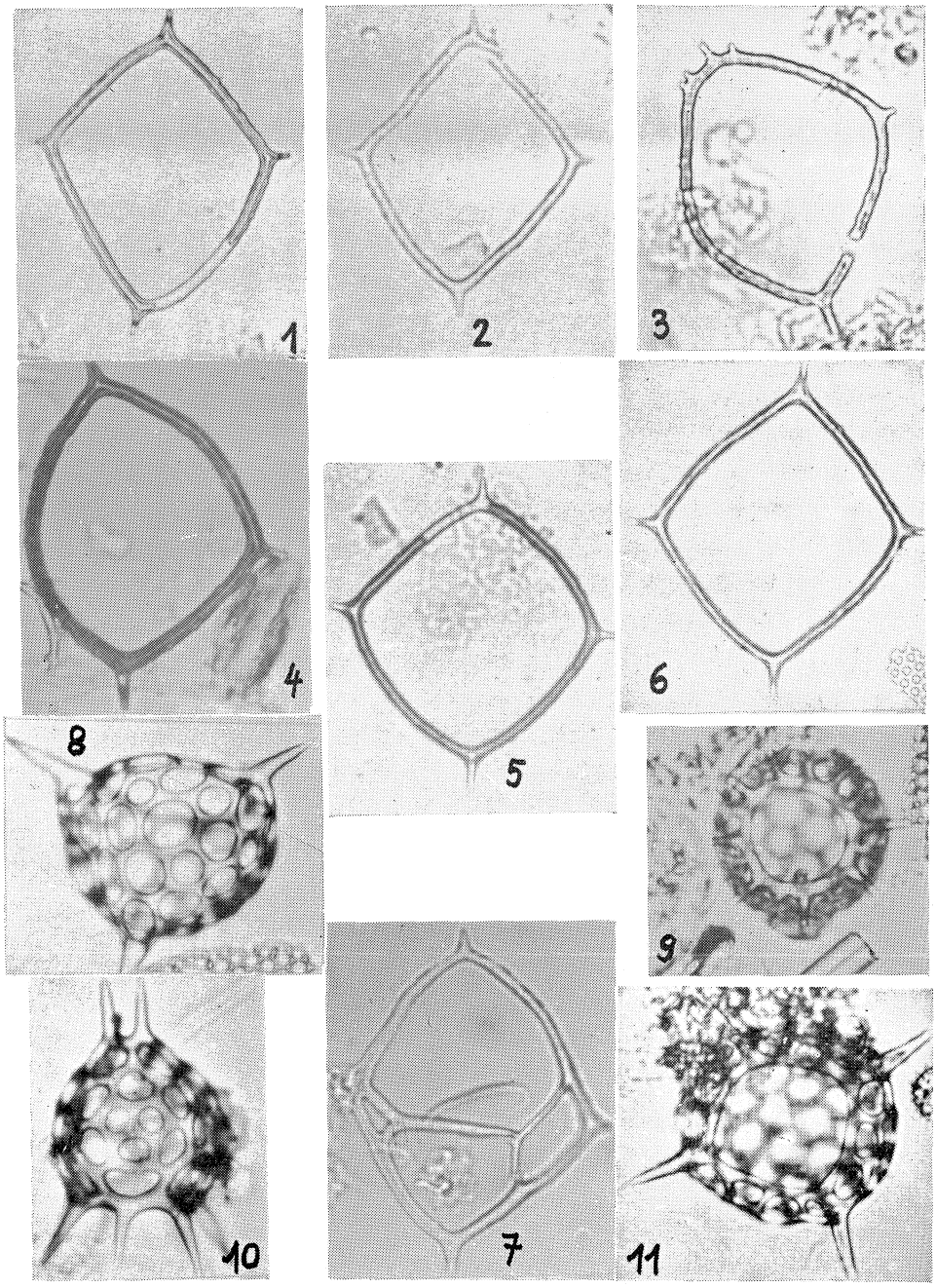

PLATE 10

Explanation of Plate 10

fig. 1-3	*Cannopilus sphaericus* Gemeinh.
fig. 4-7	*Cannopilus ernestinae* Bachmann
fig. 8	not identified anomalous skeleton

Plate 10